GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ____

Project No. E-18-611 (Q5055-2A0) ~~GTRC~~/GIT DATE 6 / 14 / 85

Project Director: M. I. Marek School/~~Lab~~ Mat.Eng.

Sponsor: DHHS/PHS/NIH/NIDR

Type Agreement: Grant 5R01-DE03601-12

Award Period: From 7/1/85 To 6/30/86 (Performance) 9/30/86 (Reports)

Sponsor Amount:	This Change	Total to Date
Estimated: $		$ 92,892
Funded: $		$ 92,892

Cost Sharing Amount: $ 6,130 Cost Sharing No: E-18-311

Title: Effect of Corrosion on Dental Amalgams

ADMINISTRATIVE DATA

OCA Contact: John Schonk x4820

1) Sponsor Technical Contact:

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National Institute of Dental Research
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National Institute of Dental Research
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Defense Priority Rating: N/A Military Security Classification: N/A

(or) Company/Industrial Proprietary: N/A

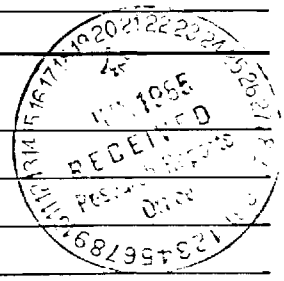
RESTRICTIONS

See Attached NIH Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT

COMMENTS:



SPONSOR'S I. D. NO. 02.108.001.85.018

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GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 11/24/86

Project No. E-18-611 School/~~XXXX~~ Mat. Eng.

Includes Subproject No.(s) N/A

Project Director(s) M. I. Marek GTRC / ~~XXX~~

Sponsor DHHS/PHS/NIH/NIDR

Title Effect of Corrosion on Dental Amalgams

Effective Completion Date: 6/30/86 (Performance) 9/30/86 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No. E-18-624

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E-11-21

SECTION IV **PROGRESS REPORT SUMMARY**	GRANT NUMBER 5R01 DE03601-13	
PRINCIPAL INVESTIGATOR OR PROGRAM DIRECTOR MAREK, MIROSLAV I.	PERIOD COVERED BY THIS REPORT FROM 07/01/85	THROUGH 06/30/86
NAME OF ORGANIZATION Georgia Institute of Technology		

TITLE *(Repeat title shown in item 1 on first page)*
Effect of Corrosion on Dental Amalgams

(SEE INSTRUCTIONS)

PUBLICATIONS

M. Marek: "An Electrochemical Test for the Evaluation of Sulfide Tarnishing of Dental Alloys," in Corrosion and Degradation of Implant Materials: Second Symposium, ASTM STP 859, A.C. Fraker and C.D. Griffin, Eds., ASTM, Philadelphia, 1985, pp. 168-178.

M. Marek: "Corrosion in a Biological Environment." International Workshop on Biocompatibility, Toxicity, and Hypersensitivity to Alloy Systems Used in Dentistry. Conference Proceedings (B.R. Lang, H.F. Morris and M.E. Razzoog, Eds.), The University of Michigan, 1986, pp. 103-122.

Presentations

M. Marek and E. Topfl: "Electrolytes for Corrosion Testing of Dental Alloys." Annual Session of the American Association for Dental Research, Washington, DC, March 12-15, 1986 (presented by M. Marek).

REPORT

1. SCIENTIFIC GOALS

No change.

2. STUDIES AND RESULTS (1985/86)

A. The Effect of Mercury on the Stability of Phases in Dental Amalgam.

The effect of the presence of mercury on the corrosion stability of some of the major phases in dental amalgam that do not contain mercury as a major alloying element was investigated. This study was based on previous observation that the reaction phase Cu_6Sn_5 in high-copper dental amalgams is more corrosion-susceptible in the presence of mercury than in pure state.

Phases Cu_3Sn, Ag_3Sn, and Pd_3Sn were prepared by melting the pure elements in vacuum and annealing. Ag_3Sn and Cu_3Sn are the major phases in alloys from which high-copper dental amalgams are prepared; Pd_3Sn is a reaction phase that has been reported to appear in the new experimental amalgams containing palladium. Samples of the above phases were prepared as electrodes and subjected to electrochemical tests. Control samples contained no mercury. The remaining samples were electrolytically plated with 1 to 10 mg/cm^2 of mercury. The corrosion potentials and anodic polarization curves of the samples exposed to synthetic saliva have been determined.

Section IV
PROGRESS REPORT SUMMARY (CONTINUED)

The results show that for all the three phases the corrosion susceptibility increased with the amount of mercury. At the highest amount of mercury there was an indication that small amounts of the Sn_8Hg (gamma-2) phase formed, sharply increasing the corrosion susceptibility. In smaller amounts mercury seemed to degrade the protective passive layer, thus increasing the passive current density and therefore the corrosion rate.

B. Determination of the Corrosion Depth as a Function of the Integrated Corrosion Current Density.

Tests were performed using one low-copper and three high-copper amalgams representing the major amalgam types on the market. Specimens were prepared according to ADA Specification #1 and subjected to controlled accelerated corrosion exposures under potentiostatic conditions. The anodic current density was monitored and integrated, providing a quantitative measure of the total corrosion damage. The specimens were then sectioned and the depth of corrosion determined after metallographic polishing.

A setback occurred due to the difficulty of identifying reliably the depth of the corroded layer. Although a surface layer of different appearance was observed in corroded specimens, scanning electron microscope examination and energy-dispersive X-ray analysis indicated that the true depth of corrosion may be, in some cases, substantially different from the one that could be observed by optical metallography. A new measurement technique involving autoradiography has been developed and is now being applied to measure more accurately the corrosion depth.

C. Investigation of Sulfide Tarnishing of Dental Amalgam

Previous results of tarnishing tests for various types of dental amalgam, and a review of literature, showed a serious lack of understanding and data concerning the electrochemical processes involved in sulfide tarnishing. Therefore, the major phases of the amalgam structure, gamma, gamma-1, gamma-2, Cu_6Sn_5, and Cu_3Sn have been prepared and subjected to electrochemical tests. The tests included measurements of the corrosion potentials, and determination of the anodic polarization curves for samples exposed to a 0.01 M aqueous sodium sulfide solution, and synthetic saliva containing 0.01 M sodium sulfide.

The results have shown that the phases containing copper had a higher thermodynamic tendency for the reactions with sulfides than silver-containing phases, but the kinetics of the formation of the sulfide films were slower on copper containing phases than on silver-containing ones. The results will be used in an overall characterization of the behavior of dental amalgam in sulfide-containing solutions.

Section IV
PROGRESS REPORT SUMMARY (CONTINUED)

3. OBJECTIVES FOR THE COMING YEAR

The following studies are planned for the coming year:

a. Investigation of the Transport of the Electrolyte Species to the Corrosion Sites within the Structure of Dental Amalgam

Radioactive tracers and high resolution autoradiography will be used to determine which species are transported to the corrosion sites, and by what mechanism. Both reactive (Cl, H, O) and nonreactive (Ca, P) species will be examined. The presence of both reactive and nonreactive species within the structure would indicate a penetration of the electrolyte as a liquid into the structure; the presence of only reactive species would indicate a solid state diffusion transport.

b. Determination of the Quantitative Relationship between Corrosion and Strength of Dental Amalgam

The bending strength of dental amalgam samples subjected to controlled corrosion will be determined. The results will be correlated with the results of the true corrosion depth measurements which are now in progress. The tests will be performed for the major types of dental amalgam, and will allow the prediction of the loss of strength for amalgams corroding at various corrosion rates.

c. Exploration of the Possibility of Stress Corrosion Cracking of Dental Amalgam

Specimens of dental amalgams representing the major types will be stressed in bending and exposed to a synthetic saliva under both free corrosion and controlled corrosion conditions. After periods of exposure the specimens will be examined by scanning electron microscopy for cracks. The study is an exploration of the possibility that stress corrosion cracking is involved in the fracture of margins of dental amalgam restorations.

d. Investigation of the Electrochemical Relationships Involved in Sulfide Tarnishing of Dental Amalgams

On the basis of the current study of sulfide tarnishing of the individual phases an analysis of the electrochemical mechanism of sulfide tarnishing of the amalgam structure will be performed. Samples simulating the amalgam structure will be prepared by mixing powders of the individual phases, and subjected to electrochemical tests. The results will be compared with the results of the same tests performed with actual dental amalgam samples, and a mechanism of tarnishing will be proposed..